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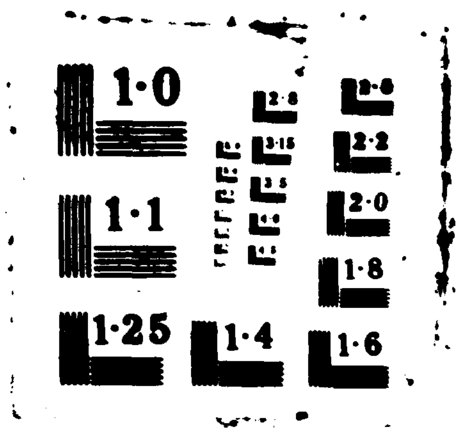
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Work with patients has shown that lesions of the posterior cortex produce a deficit that affects ability to report letters on the contralateral side of a nonsense string but has little effect on words. We have proposed that this is the result of a deficit in visual spatial attention. The current studies use cues on the left and right of foveally centered letter strings to bias visual spatial attention in normals. The studies show that the cues serve to bias report to the cued side very strongly for nonword letter strings and are less effective the more wordlike the string becomes. These results show that covert attention controls access of letters to consciousness in those cases where spatial attention is used to organize input.

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CUEING SPATIAL ATTENTION DURING PROCESSING OF WORDS AND LETTER STRINGS IN NORMALS.

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Cueing Spatial Attention During Processing of Words and Letter Strings in Normals (1)

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ABSTRACT

Work with patients has shown that lesions of the posterior cortex produce a deficit that affects ability to report letters on the contralateral side of a nonsense string but has little effect on words. We have proposed that this is the result of a deficit in visual spatial attention. The current studies use cues on the left and right of foveally centered letter strings to bias visual spatial attention in normals. The studies show that the cues serve to bias report to the cued side very strongly for nonword letter strings and are less effective the more wordlike the string becomes. These results show that covert attention controls access of letters to consciousness in those cases where spatial attention is used to organize input.

INTRODUCTION

The superiority of words over nonwords in different tasks has led cognitive psychologists to develop theories about how visual words automatically attain an integrated word form (LABERGE & SAMUELS, 1974; REICHER, 1969). Many current models emphasize parallel interactive processing for words (McCLELLAND & RUMELHART, 1981; RUMELHART & McCLELLAND, 1982). We have shown that patients with attentional deficits, produced by posterior cerebral lesions, identified words correctly even when they failed to report letters in nonwords contralateral to the lesion (extinction), (SIEROFF, POLLATSEK & POSNER, submitted).

It has already been demonstrated that a spatial cue can increase the efficiency of processing visual targets via a shift of covert attention (JONIDES, 1981; POSNER, WALKER, FRIEDRICH & RAFAL, 1984). If patients have a deficit of visual spatial attention, it should be possible to obtain results with normals that are similar to those found in patients. We use cues to draw attention to the start or end of letter strings. We use a whole report technique to measure the accuracy of identification of each letter of the string and thus, we can observe the effects of the cue throughout the string.

In our first experiment we compare cueing of words with pronounceable nonwords (pseudowords). In a second experiment, we compare cueing pseudowords with non pronounceable nonwords (illegal nonwords). We expect that illegal nonwords will show the largest cueing effects, pseudowords next and real words will show little or no cueing effect.

In previous work with patients (SIEROFF & MICHEL, In Press; SIEROFF, POLLATSEK & POSNER, Submitted), compound words have had results identical to other words. In Experiment I half the word stimuli were compound words. In our third experiment we compare these normal compound words with stimuli where the two parts of the compound have been interchanged. If the word-form integration is based on the whole item, reversed compounds should show greater attentional affects than real compounds. If integration is only for individual morphemes, reverse compounds should be the same as real compounds since each half is a real word.

EXPERIMENT 1. WORDS VERSUS PRONOUNCEABLE NONWORDS

In this experiment we compare cueing effects on words and pseudowords. The stimuli are the same as the stimuli used in our studies on patients (SIEROFF, POLLATSEK & POSNER, Submitted).

Methods

- Stimuli:

The stimuli were 120 eight-letter words and 80 eight-letter nonwords. Half of the words were compound words made of two four-letter morphemes. A minority of the non compound words were affixed words. In the compound words the mean frequency of the first morpheme was 594 (SD = 1061) and the second morpheme was 414 (SD = 521) (KUCERA & FRANCIS, 1967). Morphemes composing compound words were much more common than the compound words themselves. Non compound words (F = 61, SD = 99) were more common than the compound words (F = 17, SD = 27). The pseudowords in some cases contained lawful two- or three-letter words.

- Subjects:

Twenty normal subjects were in the experiment: thirteen women and seven men. Nineteen were right handed and one was left handed. The mean age was 31 ranging from 16 to 60. All subjects were skilled readers. Subjects viewed the display binocularly and were instructed to fixate the center of the screen.

- Procedure:

Stimuli were presented on a video screen driven by a microcomputer Apple IIe. Although the distance between the eyes of the subjects and the video screen was not fixed, the visual angle of the stimulus was around eight degrees, one degree per letter (four degrees in each hemifield). Each trial began with the presentation of a fixation cross in the middle of the screen. The fixation cross was present for 500 ms and disappeared. A spatial cue, a digit (1 to 9) appeared laterally under the first or eighth letter for 83 ms (same duration for each block). Immediately after the digit disappeared, the stimulus string was presented in uppercase letters for a duration of 200 ms for pseudowords and 33 ms for the words. Different durations were used to reduce the overall superiority of recognition for words. A pattern mask made of asterisks was presented with the offset of the string and stayed on the screen until the next trial. Trials were triggered by the experimenter once the response was given. Stimuli were randomized for each subject.

Subjects were told to report the digit first as accurately as possible, and then the stimulus. They were told to report as much as they could of the stimulus. They were told to spell the stimuli or pronounce them. They could name a word if they thought the stimulus was actually a word or close to a word. They were encouraged, when spelling the stimulus, to respect the correct order left to right. Words and pseudowords were presented in separate blocks and subjects knew in advance what type of stimulus was presented in each block. Half of the subjects received the word block first, half received the nonword block first. A practice block mixing 12 words and nonwords (150 ms) was presented first. The total experiment was one hour long.

Results

- Rules of scoring:

The stimulus was decomposed in three segments: first three letters (left segment), fourth and fifth letters (middle segment) and last three letters (right segment). We scored the accuracy of the response, using three methods (see SIEROFF, POLLATSEK & POSNER, , for details). The first method scored the identification of a letter independently of the ordering. The second method scored the correct identification of a letter and the correct place of each letter. The third method scored the correct identification and the correct ordering of a complete segment.

We are interested in the difference of performances in the left and right segment after a left or right cue. A measure of the difference between these two segments is represented by the Laterality Index (L.I.) defined by: 100 x (R - L)/(R + L). R represents the total score of the right segment and L the total score of the left segment. If L.I. is positive, it means that the highest score is on the right segment; a maximum score of + 100 means that the score on the left segment is null. When L.I. is negative, that means that the highest score is on the left segment. A Laterality Index equal to 0 means no asymmetry.

We first calculated how many letters were correctly identified for each trial (method 1). These results are presented in Table 1.

INSERT TABLE 1

A three way within subjects ANOVA was computed with Order (Words first or Pseudowords first), Stringtype (Words or Pseudowords) and Cue (Left or Right). A main effect for Stringtype emerged [$F(1,18) = 120.5$; $p<.01$] showing that words were better identified than nonwords. However, Table 1 shows that an appreciable number of errors were made in both cases.

The Laterality Index between the Left and the Right segment was then calculated (see Table 2). A three way within subjects ANOVA was computed with Order (Words first or Pseudowords first), Stringtype (Words or Pseudowords) and Cue (Left or Right). For most results there was no strong difference between the three methods and only results of the first method will be presented.

INSERT TABLE 2

A main effect for Stringtype emerged [$F(1,18) = 36.4$; $p<.01$]: words showed a very small advantage for the last letters while pseudowords had a leftward bias (most pseudowords were spelled). The Cue was significant [$F(1,18) = 5.3$; $p<.05$] as well as the interaction Stringtype x Cue [$F(1,18) = 4.4$; $p<.05$]. A one-way repeated measures ANOVA was computed with Cue (Left or Right) as factor. For pseudowords the Cue was significant [$F(1,19) = 5.3$; $p<.05$], but not for words [$F(1,19) = .8$; p=n.s.].

The Order of blocks was not significant [$F(1,18) = 1.3$; $p=.27$], neither were the interactions of Order with Stringtype, with Cue and with Stringtype x Cue. Indeed, looking at the data (Table 2), we notice that, when subjects began with words, the Laterality Index was less negative for words as well as for nonwords than when they began by nonwords. However, there was no strong difference in the response strategy for pseudowords which were spelled most of the time. Words were more frequently spelled when subjects began with pseudowords. The fact that words and pseudowords were presented in separate blocks explains why the favorite strategy for pseudowords was spelling although this was not the case in mixed blocks (SIEROFF, POLLATSEK & POSNER). We have found with patients that the different attentional effect for pseudowords and words occurred in both pure and mixed blocks.

It might be that the lack of a cue effect on words was due to the report strategy. We then looked at errors in words only in those cases when the correct word was not recognized and the response was not a word. In this case subjects usually named individual letters. A three-way ANOVA using the first scoring method was computed with the same factors. No significant effects were found. Cue did not approach significance [$F(1,18) = .5$; p n.s.].

The cue was almost perfectly identified (see Table 3) and there were no significant differences between the identification of the left and the right cue for each block (words and pseudowords).

INSERT TABLE 3

Discussion

We clearly reproduced the results shown by patients. The cue produces better performances on nearby letters for pseudowords but not for words. Thus word-form integration occurs without the requirement of attention, allowing the string to be processed as a unit when it is a word. Even when the correct word was not identified and some letters were recognized in the whole display, these reports were not influenced by the cue.

Despite differences in exposure duration, subjects were better with words than with pseudowords. Thus, an argument could be that there is some kind of ceiling effect in case of words. Only 12% of individual letters of the words were incorrectly identified. However, 28% of the whole words were in errors and this should be sufficient to show an effect of the cue if there was one. Secondly, there was no effect of the cue even on those trials in which the word was not recognized and the response was individual letters.

Another possibility is that subjects change their attentional strategy when the word block is presented. It is known that the context of the items presented with pseudowords has an effect on the processing of these pseudowords (CARR, DAVIDSON & HAWKINS, 1978). However, in our patient study, the same interaction between words and pseudowords occurred in mixed as well as in separate blocks. Moreover, in the present experiment the absence of effect of the cue on words is not influenced by the order of blocks. Subjects might have treated the lateralized cue differently in words and nonwords blocks. This was not the case since there was no difference in the identification of the left and the right cue in each condition (Table 3).

EXPERIMENT 2.

PRONOUNCEABLE NONWORDS VS. NON PRONOUNCEABLE LETTER STRINGS

The eight letter nonwords used in the last experiment were pseudowords. These are supposedly pronounceable. However, because they are long, these pseudowords are not always pronounced. Mixed with word stimuli, these pseudowords are frequently confused with similar words. It has been proposed (BARON & THURSTON, 1973) that the superiority of pronounceable nonwords over non pronounceable nonwords is a consequence of spelling regularity (in the sense of the "spelling patterns" proposed by GIBSON, PICK, OSSER & HAMMOND, 1962), regardless of pronounceability per se. These pseudowords obey standard rules for the combination of letters. Other theories explain the advantage of pseudowords over other nonwords by the easier recognition of subword units (GLUSHKO, 1979). In the case of words, these subword units could be an intermediate level of processing between the letter level and the word level. Each of these subword units would represent a somewhat common segment, i.e., a group of letters frequently encountered in words and easily recognized even out of their context. Another possibility is that these pseudowords can activate directly some lexical entries (McCLELLAND & JOHNSTON, 1977) and this, in return, will facilitate their recognition. Whatever the model we choose, pseudowords are more wordlike than non pronounceable nonwords (or illegal nonwords). According to our previous statements illegal nonwords should demonstrate a stronger attentional bias of the cue than pseudowords do.

Methods and Procedure

The methods are similar to the first experiment.

Forty eight-letter pseudowords (some of those used in the previous experiment) and forty eight-letter illegal nonwords were randomly mixed in the same block. The same letters were used for both types of stimuli. For example, the pseudoword **BLANIFER** became the illegal nonword **LBAIENFR**.

Fifteen subjects, who were not in the first experiment, participated in this study, 8 women and 7 men. There were 4 left handed and 11 right handed. The mean age was 29 and ranged from 18 to 49.

The exposure duration was 83 ms for the digit and 150 ms for the stimuli. Subjects had to name the digit first, then to report as much as possible of the stimulus. They were free to choose the report strategy and knew that some stimuli were pronounceable and others were not. As a result all the subjects spelled the stimuli. A practice trial of 16 stimuli was presented first.

Results

We present the results for each scoring method because some differences occurred. The third scoring method is used to examine the question of sub-units.

- First scoring method, (indicating the recognition of letters).

The overall performances are shown in Table 4. A two-way repeated measures ANOVA was computed with Stringtype (Pseudowords versus Illegal nonwords) and Cue as factors. Only the Stringtype effect was significant [$F(1,14) = 43.2$; $p<.01$] showing that pseudowords were identified better than illegal words.

INSERT TABLE 4

The Laterality Index using all scoring methods is shown in Table 5. A two-way ANOVA using the first scoring method showed a main effect of the Cue [$F(1,14)=30.6$; $p<.01$] and the interaction Stringtype x Cue [$F(1,14) = 6.3$; $p<.05$] indicating a stronger cueing effect for illegal nonwords than for pseudowords. However, both types of nonwords showed a highly significant effect of the cue, as shown by a one-way ANOVA: [$F(1,14) = 14.7$; $p<.01$] for pseudowords, [$F(1,14) = 41.4$; $p<.01$] for illegal nonwords.

INSERT TABLE 5

- Second scoring method (indicating that a letter was correctly identified and correctly placed in the recall).

The difference in overall performance was stronger than with the first score (Table 5). For the Laterality Index only the cue effect is significant. The interaction Stringtype x Cue did not reach significance [$F(1,14) = 3.2$; $p = .09$] although the results were in the same direction as for the first scoring. Thus, there was no additional effect of pronounceability on the ordering of letters.

- Third scoring method (correct recall in a correct order of a total segment).

Although nonwords were not built deliberately for this goal, we assumed that the third score would reflect subword unit processing. The Laterality Index was not an interesting measure because the right segment was rarely correct, due to the memory load. However, performance on the first segment was quite interesting because it was usually well recognized in both types of nonwords. If the reason pseudowords showed a smaller cueing effect was a processing by groups of letters, this should be shown by the effect of the cue on the first segment. Results are shown in Table 6. A two-way ANOVA was computed with Stringtype and Cue as factors. There was a Stringtype effect [$F(1,14) = 54.5$; $p<.01$] with a better recognition of the first segment in case of pseudowords, as expected. The cue was also significant [$F(1,14) = 11.7$; $p<.01$]. However, the interaction Stringtype x Cue did not reach significance [$F(1,14) = .01$; p n.s.].

INSERT TABLE 6

We also calculated performances of the first and last two-letter segments. Results are shown in Table 6. A three-way ANOVA was computed with Stringtype, Segment (First and Last) and Cue as factors. A main effect was found for Stringtype [$F(1,14) = 57.3$; $p<.01$], showing that two letter clusters were better recognized when they obeyed spelling rules. The Segment effect [$F(1,14) = 45.7$; $p<.01$] showed the best performance on the first segment. The asymmetry between the two segments was stronger in case of illegal nonwords, as shown by the significant interaction Stringtype x Segment [$F(1,14) = 8.6$; $p<.05$]. The effect of the cue was about the same in both classes of nonwords as shown by the non significant interactions Stringtype x Cue [$F(1,14) = 1.2$; $p=.29$] and Stringtype x Cue x Segment [$F(1,14) = .04$; p n.s.]. Other results were the expected highly significant effects of the Cue and the interaction Cue x Segment.

In conclusion, the main result is a stronger effect of the cue in the case of illegal nonwords (almost reversing the usual asymmetry) than in case of pseudowords. The stronger cueing effect on illegal nonwords does not seem to be explained by processing of letter clusters since there was no significant difference in cluster performance with any of the scores. A possibility is that pseudowords show a milder effect of the cue because more letters are recognized. There are several arguments against this. First, performance differences are relatively small (see Table 4). Secondly, if overall performance is the explanation, we should see an especially strong cue effect when the cue is on the left side. This is because less correct letters are reported and thus illegal nonwords should show a much smaller number of correct letters at the end. However, the strong difference between both strings is when the cue is on the right side. Thirdly, although difference in correct report was larger with the second score it did not show a significant differential effect of the cue.

Discussion

As predicted, the cueing effect was more striking in case of illegal nonwords than in case of pseudowords. This difference is not an effect of strategy, since both stimuli were spelled. However, it is easier to remember and to spell **B.L.A.N.I.F.E.R.** than **L.B.A.I.E.N.F.R.** but the difference of the cue could not be explained by the small difference in overall performance. A possibility is that because pseudowords are decomposed in small letter clusters (from the "spelling pattern" to the subword unit) an attentional scanning is faster than in case of a letter-by-letter focusing. However, we did not find any evidence for this hypothesis with the third scoring method. Another possibility is that the wordlike aspect of pseudowords reduced the attentional bias by activating lexical entries.

CUEING EFFECTS ON MORPHEME PROCESSING

Compound words are useful in the study of lexical access, because they are composed of two relatively independent morphemes, both of which are already represented in the lexicon. These two morphemes form a new morphological and semantic unit. The new meaning is sometimes not clearly associated with the meaning of each morpheme (bluebell, handsome). Although studies on compound words are quite scarce two main theories about their lexical access have been proposed.

OSGOOD & HOOSAIN, in 1974, proposed lexical access by the whole compound words considered as a single semantic unit. They showed that the recognition threshold of nominal compound words (made of two morphologically separated words, like in "post card") was lower than for compounding ordinary noun phrases, in which constituent words retained their individual meaning. Secondly, they found the recognition threshold of compound words, when presented after their components, was lower than when first presented. However, this facilitation was not found for the components themselves presented after the compound word.

A different view was proposed by TAFT & FORSTER (1976). For them, the stem of an affixed word, not the word as a whole, is the target for lexical search. In case of compound words the lexical entry is accessed by the first morpheme. In a lexical decision task they showed that the reaction times were similar for nonwords made up of two short non-related words and nonwords made of a short word followed by nonsense letter string. These reaction times were longer than those for nonwords in which the first segment was not a word. The stimuli they used were all nonwords. Left to right scanning can explain the longer reaction time for nonwords in which a complete scanning is necessary to the decision. They also showed that compound words with a first morpheme of high frequency were faster to classify in a lexical decision task than those with a first morpheme of low frequency. However, they did not report the effect of the frequency of the second morpheme or the whole word, although the authors mentioned: "the decision that the second constituent can go together with the first constituent is likely to be influenced by the commonness of that constituent combination, that is, the frequency of the word as a whole".

If compound words gain access to the lexicon as a unit there should be no spatial scanning necessary for their processing. In a previous study (SIEROFF & MICHEL, In press), patients who extinguished a word contralateral to the lesion did not extinguish the contralateral part of centered words, even if these centered long words were compound words. Some patients with a left hemisphere lesion showed a right sided extinction for centered words as well. In this case, the extinction was not stronger for compound words than for other words. The sparing of compound words from extinction has been reproduced in another study (SIEROFF, POLLATSEK & POSNER,). We will first present the results for compound words in Experiment 1 of this paper, then compare attentional effect on compound words and nonwords.

Half of the words of the first experiment were compound words. A three-way ANOVA was computed with Order (Words first or Nonwords first), Stringtype (Compound or Non Compound) and Cue (Left or Right) as factors. The only significant effect was Stringtype [$F(1,18) = 6.1$; $p<.05$] showing that more letters were identified in case of non compound words than in case of compound words. This can be explained by their difference in frequency; some of the compound words are actually very rare words.

The Laterality Index is shown in Table 7. A three-way ANOVA was computed with the same factors. The only significant effect was the Order, with a positive L.I. when words were presented first, and a negative L.I. when words were presented after the nonwords. The Cue was not significant [$F(1,18) = 1.2$; $p=.29$], and neither was the interaction Stringtype x Cue [$F(1,18) = 1.5$; $p=.23$], showing that the cue had no effect on compound words.

INSERT TABLE 7

ılated the percentage of correct report of each of the two morphemes ɔund words irrespective of the order of these morphemes. A NOVA was computed with Order, Morpheme (Left or Right morpheme of d word), and Cue. The Morpheme was not significant [$F(1,18) = 1.7$; ing that, overall, the left morpheme was not better recognized than ne. However, the interaction Order x Morpheme was significant 4.4; $p<.05$]: when subjects began by the block of nonwords they were ne first morpheme. The Cue effect was not significant but the level of significance [$F(1,18) = 3.7$; $p=.07$] and the interaction was significant [$F(1,18) = 5.3$; $p<.05$]. However, the effect of the an enhancement of the recognition of the morpheme on the same side. en subjects had the block of words first, identification of the left ht morpheme was better when the cue was on the left. This small bias is not completely surprising because in normal reading we htly to the left of the middle of the words. Since this effect did he left morpheme we conclude that the cue had *no* spatial effect and und words were processed as a whole, at least most of the time.

ed at the effect of the frequency of the compound words (KUCERA & 67). There was not a strong relation of frequency to correct . Only those nine words that have a frequency inferior to 1 in this somewhat less well recognized (50%) than the others (75%). ere more common than the whole compound words. However, the rds were recognized in 69% of the cases, no morpheme was recognized m letters) 23% of the time and in only 8% of the cases one morpheme zed. When one morpheme was recognized it was the most common one in the cases showing that frequency did not play an important role in tion of these morphemes. In fact, on the 90 times only one morpheme zed, it was included 62 times in another compound word, 10 times in se, 6 times in a nonsense compound and 12 times alone or with some

ERIMENT 3: COMPOUND WORDS AND POLYMORPHEMIC NONWORDS

study were presented compound words mixed with nonwords made of two These morphemes came from a genuine compound word and were reversed ecomes YARDBACK)[3]. The subjects knew that these two types of e going to be presented.

procedure

hods were similar to the first experiment.

f the eight-letter compound words used in the first experiment were two groups of equal frequency. The words of the first group were to "reverse" nonwords. The words of the second group were not .

e fifteen subjects who participated in the second experiment were s study.

The exposure duration was 83 ms for the cue and 33 ms for the stimulus. The two types of stimuli were randomly mixed. Instructions were made clear about the nature of the stimuli. Subjects had to identify the digit first, then to identify the stimulus. They were encouraged in case of reverse nonword not to reconstitute the formal compound word but to recall what they saw.

Results

The number of correct letters for each stimulus was calculated and was 7.0 for compound words and 6.4 for reverse compounds. A two-way ANOVA was computed with Stringtype (Compound or Reverse) and Cue as factors. A main effect of Stringtype was found [$F(1,14) = 7.4$; $p<.05$] with better performance on the words. The Cue had no significant effect but the interaction Stringtype x Cue was significant [$F(1,14) = 6.6$; $p<.05$]: there was a slightly better recognition of letters of the compound words when the cue was on the left and a better recognition of the letters of the reverse nonword when the cue was on the right.

The Laterality Index was then calculated (Table 8). A two-way ANOVA was computed with the same factors. The Cue was significant [$F(1,14) = 5.3$; $p<.05$] as well as the interaction Cue x Stringtype [$F(1,14) = 5.4$; $p<.05$]. A one-way ANOVA with Cue as factor showed that the Cue had a significant effect in case of reverse nonwords [$F(1,14) = 9.1$; $p<.01$] but not in case of compound words [$F(1,14) = .00$; p n.s.].

INSERT TABLE 8

We calculated the time each morpheme was correctly pronounced disregarding the order of report (Table 9). A three-way ANOVA was computed with Morpheme (left or right of the stimulus), Stringtype and Cue as factors. Significance was reached only by Stringtype [$F(1,14) = 13.2$; $p<.01$] (showing better performance for words), and the interaction Morpheme x Stringtype was significant [$F(1,14) = 5.3$; $p<.05$]. The interaction was due to a better identification of the left morpheme over the right morpheme in case of reverse nonwords and not in case of words. The cue had no effect [$F(1,14) = .3$; p n.s.] and neither did the interaction of Cue with Stringtype [$F(1,14) = 3.0$; $p=.1$] and with Stringtype x Morpheme [$F(1,14) = .08$; p n.s.].

INSERT TABLE 9

Discussion

Compound words did not show any strong cue effect, but "reverse" polymorphemic nonwords did. The effect on these nonwords were almost as strong as the one found in other "real" pseudowords of the first and the second experiments.

In Experiment 3 morphemes of the polymorphemic nonwords were recognized only in half of the cases, with a superiority for the left one. The cue was effective specifically in those cases when the nonwords were spelled, i.e., when no morpheme was recognized.

Our data are in agreement with a lexical access of the whole compound word as proposed by OSGOOD & HOOSAIN, (1974) and with the availability, in certain circumstances, of a decomposition strategy (RUBIN & BECKER, 1979).

CONCLUSION

This set of experiments followed a strategy of attempting to reproduce in normals a deficit found in patients. The first step in this procedure was to define the posterior cortical deficit as one of visual-spatial attention. In our previous work (SIEROFF, POLLATSEK & POSNER,) we showed how this deficit led to an extinction of the contralesional side of nonwords but there was little spatial deficit for words. The next step was to adopt a method designed to vary attention to foveal words in normals. To do this we required subjects to report a cue digit to the left or right of the letter string prior to their report of the target. We assumed that the digit would cue covert attention to the side of the cue. Our experiments show that under these conditions normal subjects tend to miss the uncued side of nonsense letter strings but there is little or no effect of the cue for words. Table 10 summarizes this effect by showing the difference in laterality index between left and right cues for words, compound words, reverse compound words, pronounceable nonwords and non-pronounceable nonwords. The more wordlike the stimulus is the stronger the effect of the cue on the laterality index. These results support the strategy of attempting to link dissociations found with lesions and effects found in normals.

INSERT TABLE 10

A common assumption in cognitive neuropsychology is that lesions do not produce new phenomena, but provide a basis for observing more clearly the operation of systems found also in normals. The current work provides support for this critical assumption.

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2. Now at Laboratoire de Neuropsychologie, Hospital Neurologique, Lyon, France.

3. Professor J. Neely made this suggestion.

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TABLE 1: WORDS VERSUS NONWORDS

The average number of correct letters reported for presentation of eight letter strings. Standard deviation is in parenthesis.

Stimulus	Left cue	Right Cue
Word	7.1 (0.8)	7.1 (1.0)
Nonwords	5.5 (.75)	5.5 (.85)

TABLE 2: WORDS VERSUS NONWORDS: PERCENTAGE CORRECT AND LATERALITY INDEX

The Laterality Index (LI) is defined by (R + L) x 100 / (R - L) in which R represents the performance of the last (right) segment of the stimulus, and L the performances of the first (left) segment of the stimulus. A positive LI indicates better performances on the right segment, a negative LI indicates better performance on the left segment.

Results are shown for the first scoring (1st) and the third scoring (3rd). Standard deviation is in parenthesis.

Stimulus	Order	Cue side	Scoring method	Segments: Left		Segments: Fovea		Segments: Right		Laterality Index	
Words	W-NW	left	1st	86.3	(13.6)	87.8	(10.8)	89.1	(9.2)	1.9	(4.1)
			3rd	76.3	(21.0)	77.7	(18.8)	79.0	(17.3)	2.5	(5.1)
		right	1st	84.6	(16.9)	84.9	(16.2)	87.3	(12.4)	2.2	(4.6)
			3rd	74.3	(24.8)	73.5	(24.6)	76.3	(21.9)	2.4	(5.2)
	NW-W	left	1st	93.6	(3.8)	88.6	(10.7)	87.2	(13.3)	-4.1	(7.5)
			3rd	83.7	(11.8)	77.5	(19.3)	77.7	(19.1)	-4.8	(9.9)
		right	1st	92.0	(5.6)	88.2	(11.5)	87.2	(13.6)	-3.2	(6.4)
			3rd	82.5	(13.1)	78.5	(19.3)	78.3	(20.5)	-4.0	(9.6)
Nonwords	W-NW	left	1st	83.4	(16.8)	66.1	(17.8)	55.7	(16.4)	-20.0	(18.9)
			3rd	54.3	(26.7)	25.8	(17.7)	10.3	(11.3)	-59.7	(47.5)
		right	1st	75.8	(20.9)	63.8	(18.1)	62.3	(13.3)	-12.3	(17.1)
			3rd	39.8	(28.2)	23.3	(14.3)	15.8	(11.1)	-20.0	(65.3)
	NW-W	left	1st	84.8	(11.3)	61.6	(11.7)	52.8	(11.3)	-23.4	(15.2)
			3rd	51.8	(26.6)	23.3	(12.3)	6.5	(4.9)	-68.1	(34.7)
			1st	82.3	(11.8)	59.5	(14.8)	59.8	(11.5)	-16.0	(14.5)
			3rd	48.3	(25.9)	21.0	(13.5)	9.8	(7.3)	-59.7	(34.0)

TABLE 3: WORDS VERSUS NONWORDS:
ACCURACY OF THE REPORT OF THE CUE (in percentage).

Standard deviation is in parenthesis.

	Left cue	Right cue
Words set	94.4 (4.8)	96.0 (4.6)
Nonwords set	95.8 (3.7)	94.0 (7.7)

TABLE 4: NONWORDS (PRONOUNCEABLE VERSUS NON PRONOUNCEABLE): OVERALL PERFORMANCES

The average number of named letters and the average number of correct letters per trial. Standard Deviation in parenthesis.

Stimulus	Measures	Left cue	Right cue
Pronounceable	Recall	7.1 (0.5)	7.0 (0.5)
	Correct	5.4 (0.5)	5.6 (0.5)
Non pronounceable	Recall	7.0 (0.6)	6.9 (0.6)
	Correct	5.1 (0.5)	5.1 (0.4)

TABLE 5: NONWORDS (PRONOUNCEABLE VERSUS NON PRONOUNCEABLE) LATERALITY INDEX

Standard deviation is in parethesis.

Stimulus	Cue side	Scoring method	Segments Left	Segments Middle	Segments Right	Laterality Index
Pronounceable	Left	1st	87.3 (12.9)	58.5 (13.6)	52.7 (13.1)	-24.9 (16.2)
		2nd	79.3 (17.2)	34.7 (11.4)	35.9 (13.7)	-37.6 (23.9)
		3rd	56.4 (29.0)	13.4 (9.6)	6.7 (9.2)	-65.9 (46.5)
	Right	1st	76.0 (10.2)	68.7 (12.8)	64.2 (11.2)	-8.6 (12.5)
		2nd	65.2 (13.2)	38.7 (14.5)	47.0 (11.4)	-16.2 (16.1)
		3rd	34.7 (20.1)	20.0 (14.4)	10.4 (8.6)	-47.9 (40.6)
Non Pronounceable	Left	1st	82.6 (9.4)	58.3 (17.1)	47.9 (11.8)	-27.0 (14.8)
		2nd	64.5 (15.1)	27.3 (11.6)	27.0 (8.7)	-40.2 (19.7)
		3rd	30.4 (21.7)	9.0 (7.6)	1.0 (2.8)	-80.0 (56.1
	Right	1st	65.1 (10.2)	65.3 (11.2)	62.2 (10.3)	-2.3 (12.1)
		2nd	47.1 (10.0)	32.3 (11.3)	37.6 (9.0)	-11.4 (16.3)
		3rd	9.0 (9.7)	15.4 (12.0)	2.7 (4.6)	-49.3 (59.9)

TABLE 6: NONWORDS (PRONOUNCEABLE VERSUS NON PRONOUNCEABLE): CORRECT IDENTIFICATION OF LETTER CLUSTERS OF THE EXTREMITIES

Results correspond to the total number of correct segments in sets of 20 stimuli for each condition. Standard deviation is in parenthesis.

6a. FIRST (LEFT) THREE-LETTER CLUSTER

Stimulus	Left cue		Right cue	
Pronounceable	11.3	(5.8)	6.9	(4.0)
Non pronounceable	6.1	(4.3)	1.8	(1.9)

6b. FIRST (LEFT) AND LAST (RIGHT) TWO-LETTER CLUSTERS

Stimulus	Cue side	Segments First (left)		Last (right)	
Ponounceable	left	15.4	(4.5)	3.6	(2.9)
	right	10.4	(3.6)	5.7	(3.0)
Non pronounceable	left	10.3	(6.1)	1.3	(1.5)
	right	4.7	(3.1)	2.5	(1.6)

TABLE 7: LATERALITY INDEX OF COMPOUND AND NON COMPOUND WORDS IN EXPERIMENT 1

Standard Deviation is in parenthesis.

Stimulus	Order	Cue Side	Scoring Method	Segments Left		Segments Fovea		Segments Right		Laterality Index	
Compound											
	W-NW										
		left	1st	84.8	(17.7)	86.0	(15.4)	87.6	(12.3)	2.3	(6.5)
			3rd	75.0	(26.4)	75.3	(24.6)	78.3	(21.3)	3.9	(8.5)
		right	1st	82.4	(19.1)	80.7	(20.6)	84.4	(15.2)	1.8	(4.9)
			3rd	71.7	(29.7)	68.3	(29.7)	73.0	(24.6)	3.4	(9.6)
	NW-W										
		left	1st	93.1	(5.2)	88.2	(10.1)	85.0	(15.3)	-5.3	(9.0)
			3rd	83.7	(13.9)	74.7	(21.6)	75.0	(22.1)	-6.9	(12.0)
		right	1st	91.7	(6.4)	86.3	(12.2)	85.1	(15.0)	-4.4	(7.5)
			3rd	82.7	(13.8)	75.3	(20.6)	75.3	(22.1)	-6.2	(10.8)
Non Compound											
	W-NW										
		left	1st	87.9	(10.1)	89.5	(7.2)	90.6	(7.1)	1.7	(2.6)
			3rd	77.7	(16.7)	80.0	(13.6)	79.7	(13.7)	1.7	(3.3)
		right	1st	86.6	(14.7)	89.0	(12.2)	90.2	(9.9)	2.5	(4.8)
			3rd	77.0	(20.2)	78.7	(20.1)	79.7	(19.7)	2.0	(3.2)
	NW-W										
		left	1st	94.0	(4.0)	89.0	(12.2)	89.4	(12.0)	-2.9	(6.3)
			3rd	83.7	(11.3)	81.3	(19.2)	80.3	(17.3)	-2.8	(8.2)
		right	1st	92.3	(6.0)	90.0	(12.8)	89.0	(12.9)	1.1	(5.9)
			3rd	82.3	(14.1)	81.7	(19.5)	81.3	(20.9)	-1.9	(8.7)

OMPOUND WORDS VERSUS "REVERSE" NONWORDS:

PERCENTAGE CORRECT AND LATERALITY INDEX (first scoring)
viation is in parenthesis.

Cue side	Segments Left	Fovea	Right	Laterality Index
left	89.8 (9.3)	88.4 (10.3)	85.2 (15.3)	-3.3 (12.0)
right	88.0 (9.9)	87.4 (10.7)	82.9 (12.5)	-3.2 (8.3)
left	86.0 (11.1)	72.4 (15.6)	70.2 (14.0)	-10.4 (12.7)
right	86.0 (12.0)	80.0 (13.5)	82.0 (14.4)	-2.6 (11.9)

TABLE 9: COMPOUND WORDS VERSUS "REVERSE" NONWORDS:
RECOGNITION OF MORPHEMES (maximum = 10 in each condition)
Standard deviation is in parenthesis.

Stimulus	Cue side	Morpheme Left		Morpheme Right	
Compound words	left	7.3	(1.9)	7.1	(1.9)
	right	6.9	(1.9)	7.0	(1.8)
Reverse non-words	left	5.5	(1.9)	4.2	(2.2)
	right	6.1	(2.3)	4.9	(2.7)

TABLE 10: CUE EFFECT ON LATERALITY INDEX ON DIFFERENT TYPES OF STIMULI (SUMMARY):

	Left Cue	Right Cue	Δ
Non compound words	- 1.2	1.4	2.6
Compound words (1)	- 3.2	- 2.3	0.9
Reverse nonwords	-10.4	- 2.9	7.5
Pseudowords (2)	-23.3	-11.4	11.9
Illegal nonwords	-27.0	- 2.3	24.7

(1) average from Experiment 1 and 3

(2) average from Experiment 1 and 2

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